MEMS-BASED VARIABLE CAPACITOR

ABSTRACT OF THE DISCLOSURE

[0099] A variable capacitor device using MEMS or micromachining techniques wherein thin-films of materials are deposited, patterned and etched to form movable micromechanical elements on the surface of a substrate composed of either semiconductor, glass, metal, or ceramic material. In one embodiment of the present invention to achieve higher frequency performance as well as other benefits, the substrate is comprised of Low-Temperature Co-Fired Ceramics (LTCC). The variable capacitor is an electrostatically actuated micromechanical device and if fabricated on a LTCC multi-layered substrate material has continuous electrical connections through the layers. The same LTCC substrate material can also be used to enclose the device by selectively removing a portion of the upper substrate so as to form a cavity. The two substrates are then bonded together to enclose and protect the variable capacitor. An integrated circuit can be incorporation onto the multi-level substrate structure to enable a electronic closed-loop controlled variable capacitor module. The integrated circuit is flip-chip bonded at the bottom of the substrate structure with appropriate electrical connections between the integrated circuit and the MEMS variable capacitor device. A variation of the present invention utilizes a zipper actuation method wherein the tuning ratio of the variable capacitor is increased to very high levels. Yet another variation of the present invention utilizes a differential gap between the top and bottom electrodes such that the actuation electrodes do not physically contact one another. Yet another implementation of the present invention uses an extra set of electrodes or mechanical mechanism so as to lock the value of the capacitor undefinitely. Yet another implementation uses shaped actuation electrodes so as to linearize the relationship between the applied actuation voltage and the resultant capacitance of the device.